

EUV resists patterning results at SEMATECH

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SEMATECH

1. Objectives

Evaluate EUV resist samples focusing on resolution, photospeed, and LWR.

Looking for the patterning solution at 16nm HP and below.

	2009 Targets (per 2009 roadmap)	2011 Targets (per 2011 roadmap)	2012 Targets (per 2011 roadmap)
½ Pitch			
DRAM ½ pitch	52	36	32
Flash ½ pitch	38	22	20
MPU Gate in resist	47	35	31
3s low freq. LWR	3.7nm	2.8nm	2.5nm

Resist sensitivities ; 5 ~ 20mJ/cm2

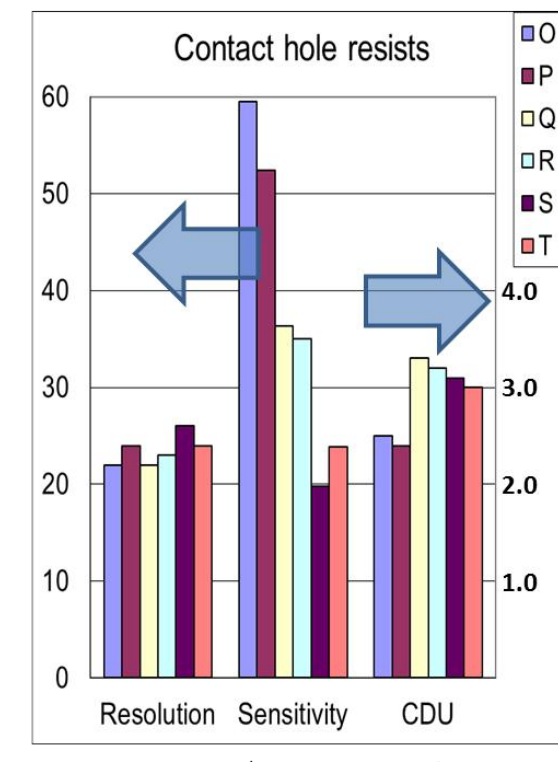
2. Tools and illumination conditions

- SEMATECH ADT
 - Conventional, 0.25 NA, sigma 0.5
- SEMATECH Albany MET
 - Quadrupole, NA 0.3, sigma 0.35/0.93 for line and space
 - Bi-convex dipole, NA 0.3, sigma 0.55/0.93 for line and space
- SEMATECH Berkeley MET
 - "18 nm dipole", NA 0.3, offset 0.63, sigma 0.15, x-offset 0.3
 - Pseudo PSM
 - Quadraole, NA 0.3, sigma 0.48~0.68 for contact hole
 - Annular, NA 0.3, sigma 0.35~0.55 for contact hole



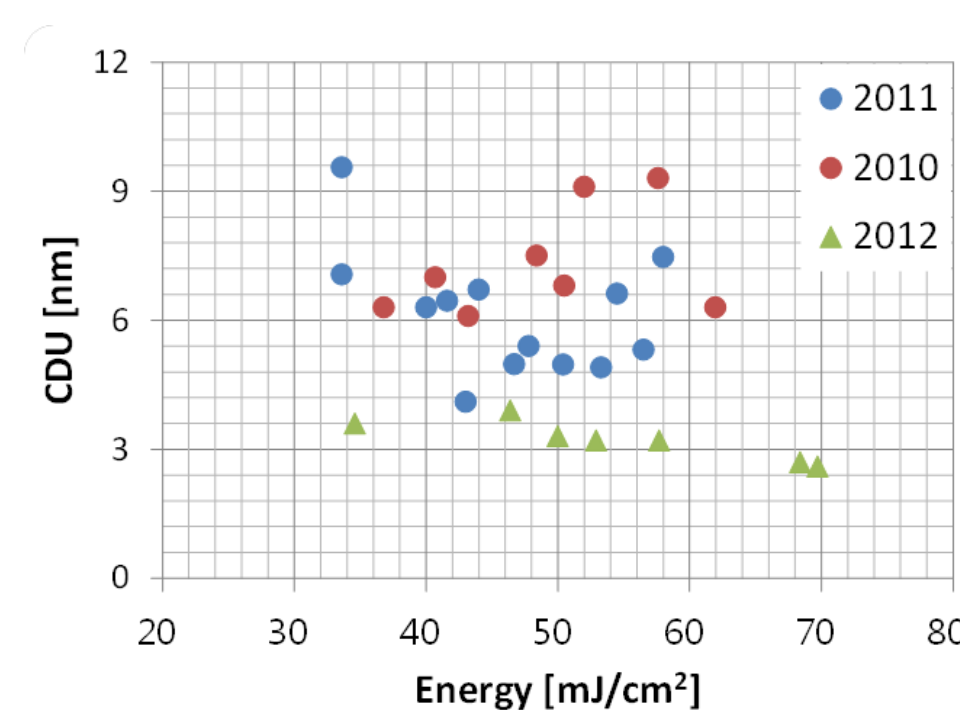
4. EUV resist performance status, contact hole

Berkeley MET
Quad, NA 0.3, sigma 0.48~0.68
FT 80nm
Underlayers
No mask bias



	28nm	26nm	24nm	23nm	22nm	21nm	20nm
O							99.5mJ/cm2 2.5nm
P							52.4mJ/cm2 2.4nm
Q							35.0mJ/cm2 3.2nm
R							19.8mJ/cm2 3.5nm
S							23.9mJ/cm2 3.0nm
T							

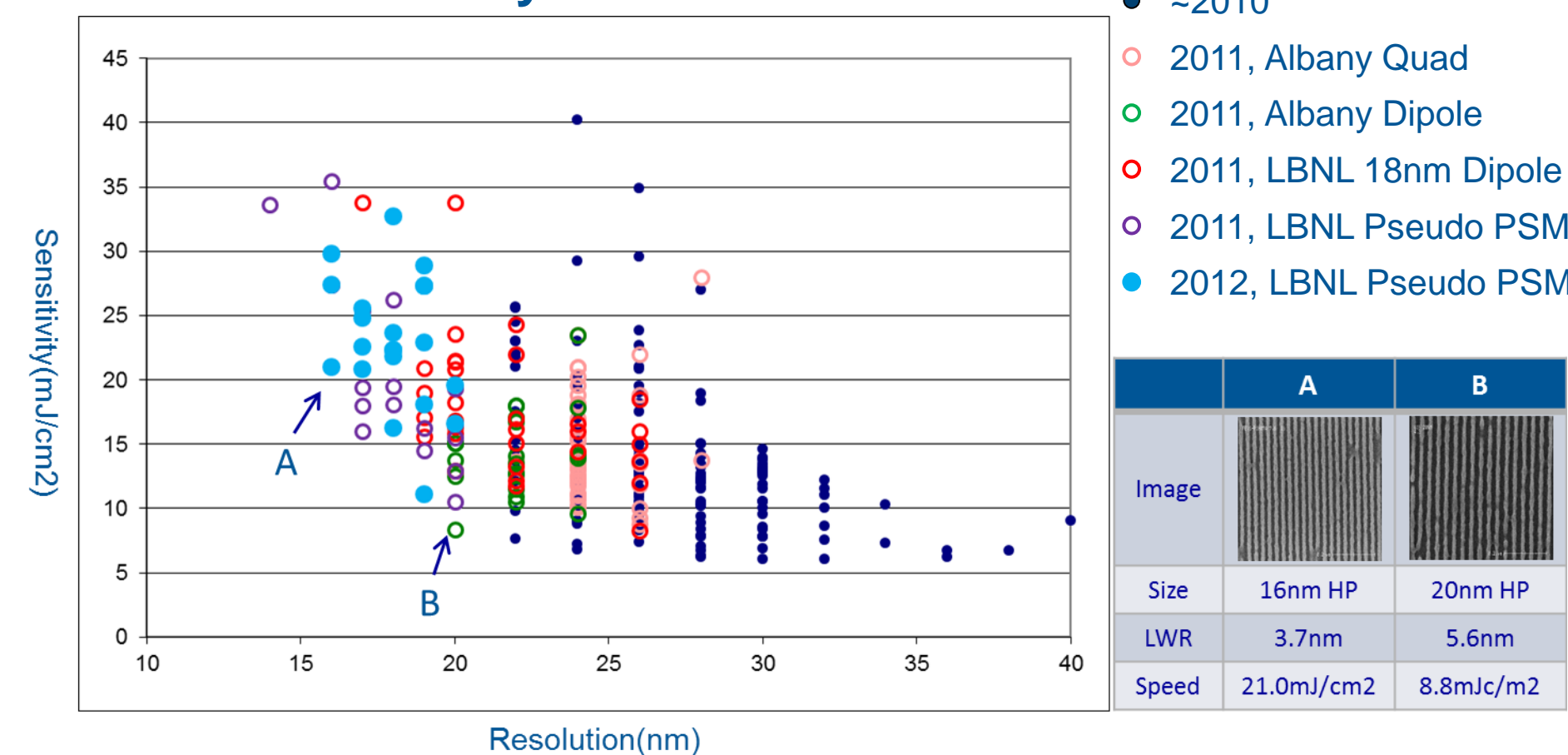
	U	V	X	Y	Z
30nm	52.9mJ 31.1nm CDU 3.2nm	68.4mJ 30.3nm CDU 2.7nm	46.4mJ 30.6nm CDU 3.9nm	69.7mJ 31.3nm CDU 2.6nm	46.5mJ 29.9nm CDU 3.3nm
35nm	43.0mJ 35.6nm CDU 3.4nm	59.2mJ 34.1nm CDU 2.1nm	40.1mJ 37.0nm CDU 2.8nm	60.6mJ 35.5nm CDU 2.0nm	



- Contact hole resists remain much slower than L/S resists
- Mask bias can help resists faster.
- CDU is improving with some resists showing sub 3 nm CDU

3. EUV resist performance status, line and space

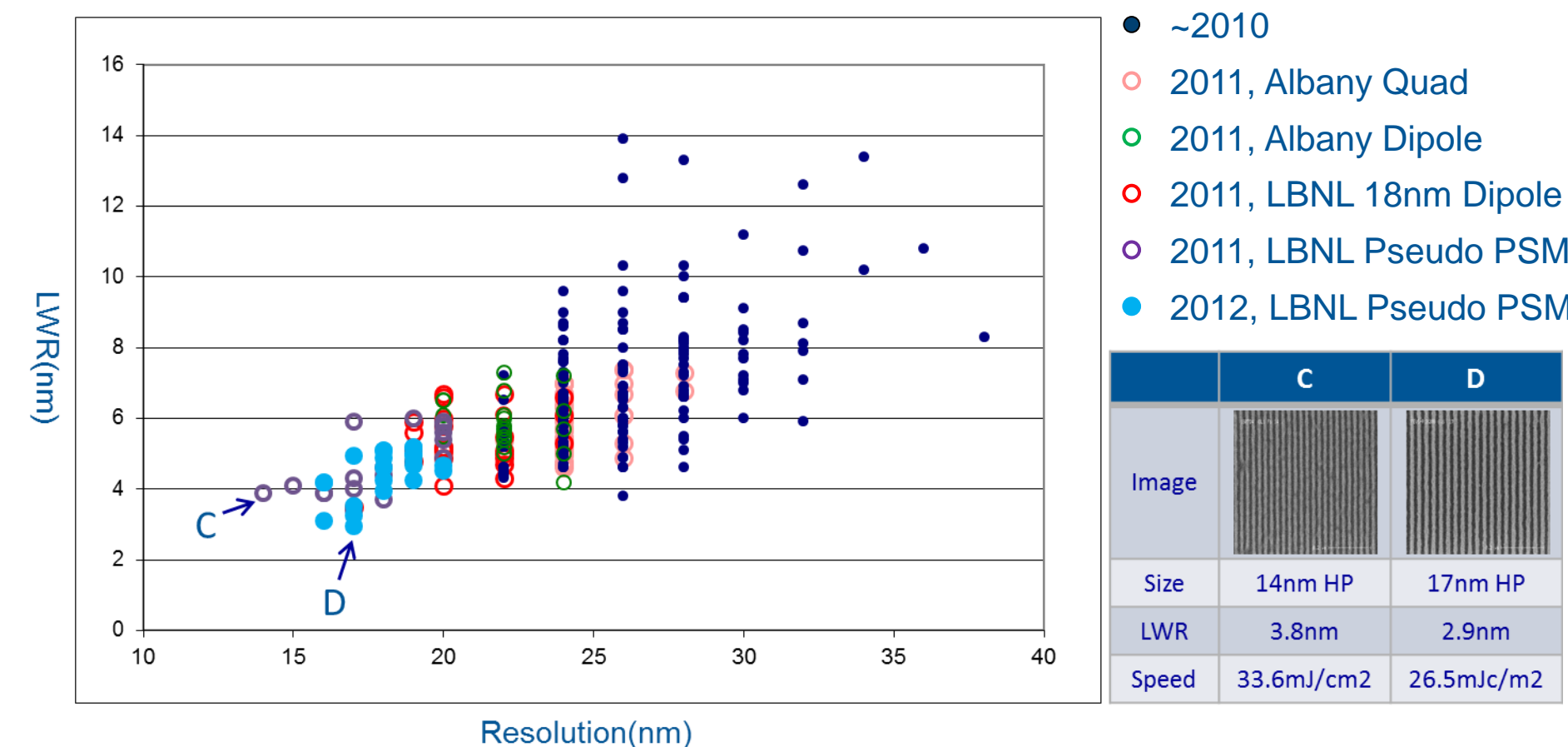
Sensitivity vs. Resolution



- ~2010
- 2011, Albany Quad
- 2011, Albany Dipole
- 2011, LBNL 18nm Dipole
- 2011, LBNL Pseudo PSM
- 2012, LBNL Pseudo PSM

	A	B
Image		
Size	16nm HP	20nm HP
LWR	3.7nm	5.6nm
Speed	21.0mJ/cm2	8.8mJ/cm2

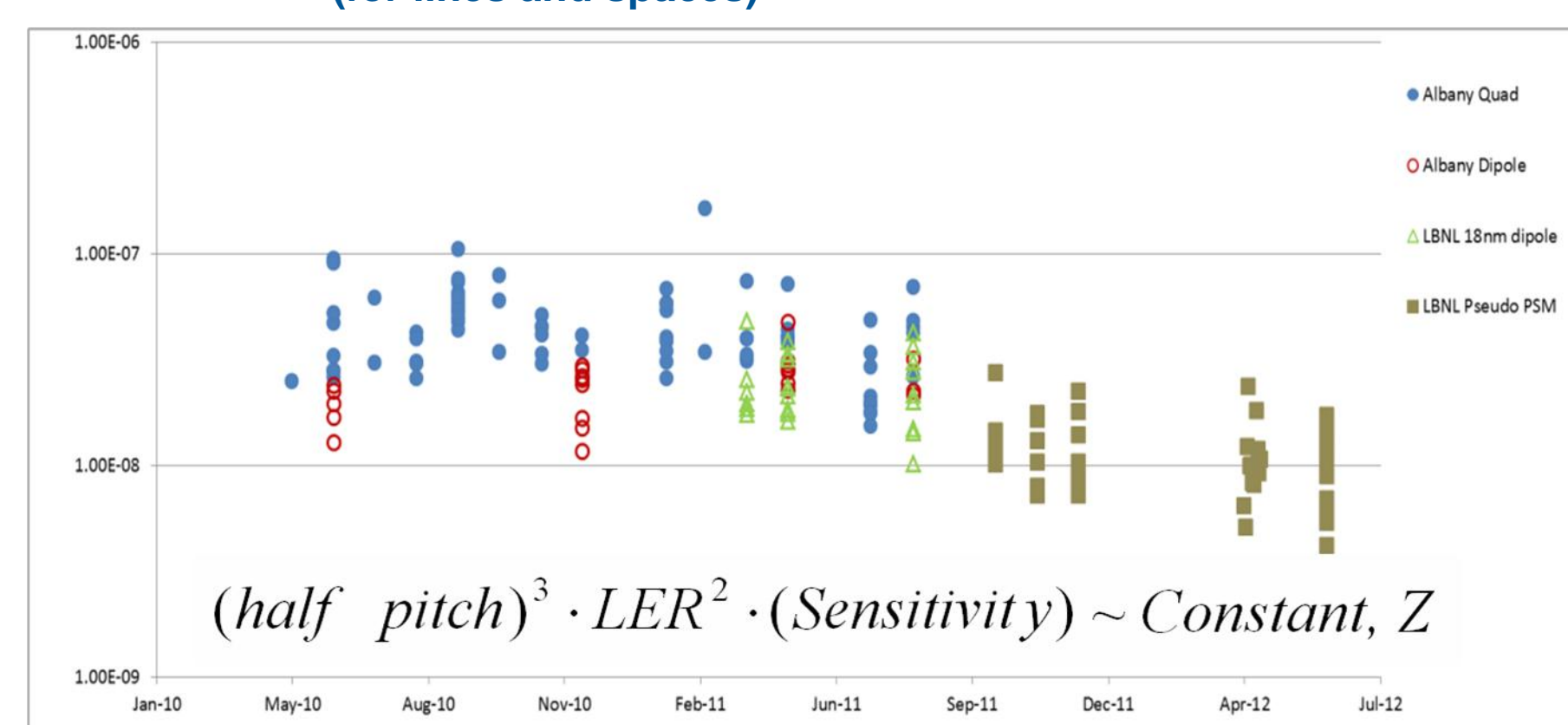
LWR vs. Resolution



- ~2010
- 2011, Albany Quad
- 2011, Albany Dipole
- 2011, LBNL 18nm Dipole
- 2011, LBNL Pseudo PSM
- 2012, LBNL Pseudo PSM

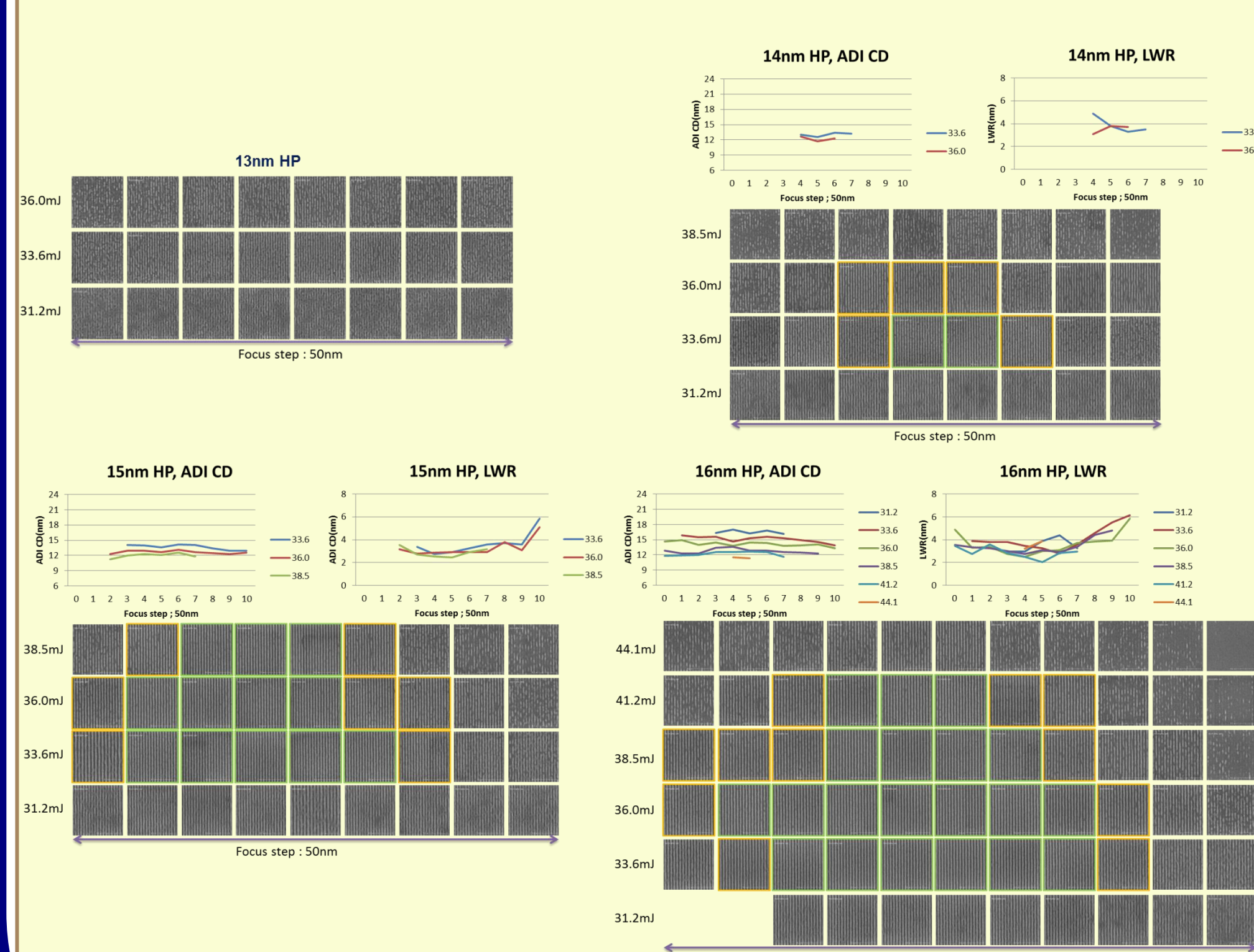
	C	D
Image		
Size	14nm HP	17nm HP
LWR	3.8nm	2.9nm
Speed	33.6mJ/cm2	26.5mJ/cm2

Z Value of EUV resists over time (for lines and spaces)



- Data represents materials from six suppliers
- Mostly improvement in Z value comes from improving the aerial image.
- Some progress in Z value due to the resist improvements is evident

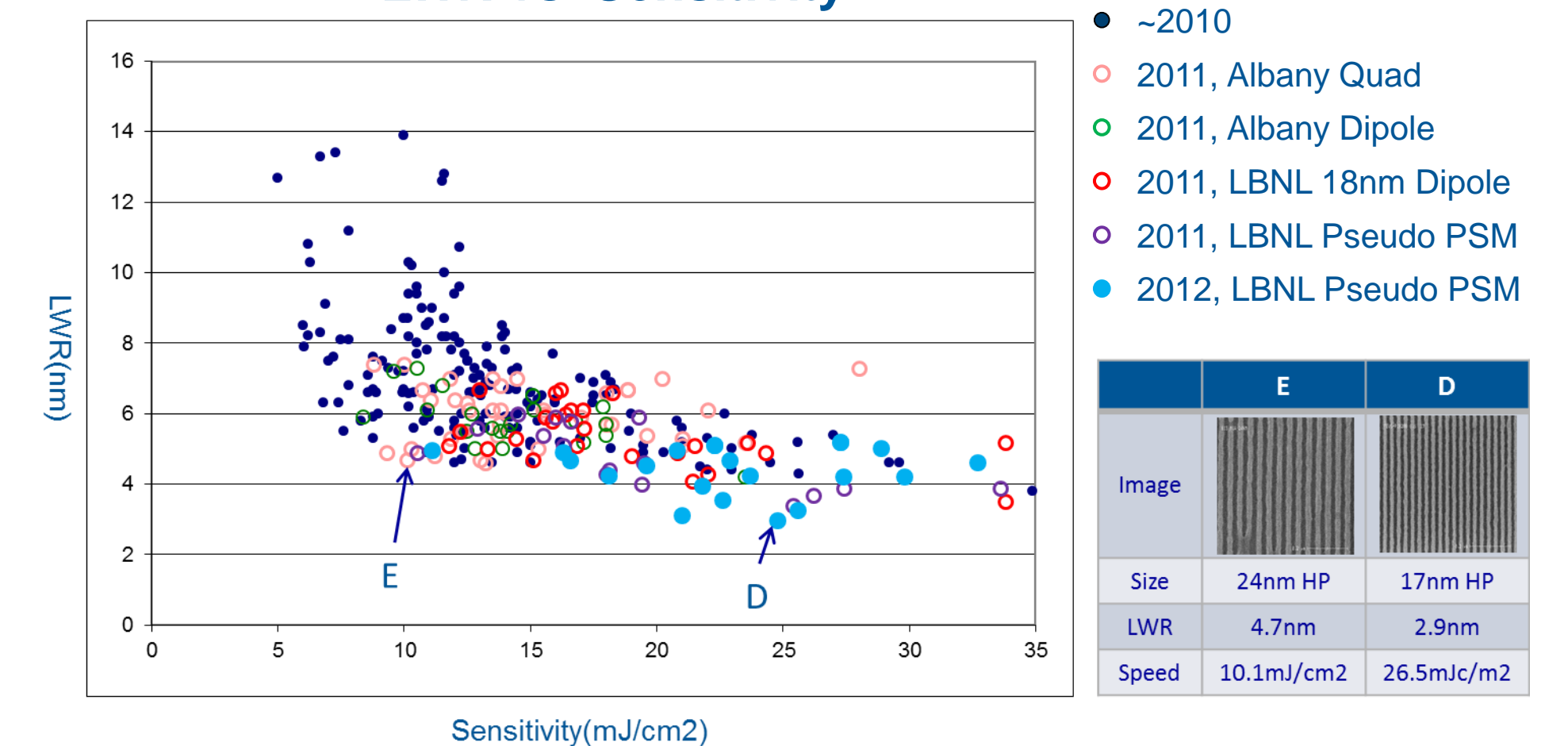
Process window of H



- Resist H had reasonable process window at 15nmHP.
- LWR is around 3nm.

- Resolution down to 15 nm has been demonstrated by using optimized illumination conditions
- Better resolution has a cost in photospeed
- There has been some improvement in best LWR recently. Best LWR is between 3nm and 4nm
- LER photospeed trade off may have improved a little
- Recent high performing resists need 20mJ/cm2 or more in dose for lines and spaces

LWR vs. Sensitivity



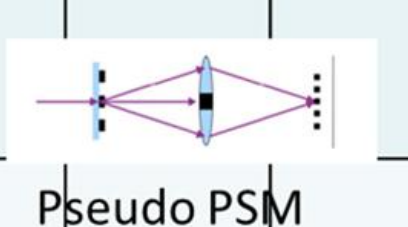
- ~2010
- 2011, Albany Quad
- 2011, Albany Dipole
- 2011, LBNL 18nm Dipole
- 2011, LBNL Pseudo PSM
- 2012, LBNL Pseudo PSM

	E	D
Image		
Size	24nm HP	17nm HP
LWR	4.7nm	2.9nm
Speed	10.1mJ/cm2	26.5mJ/cm2

Best materials from each supplier

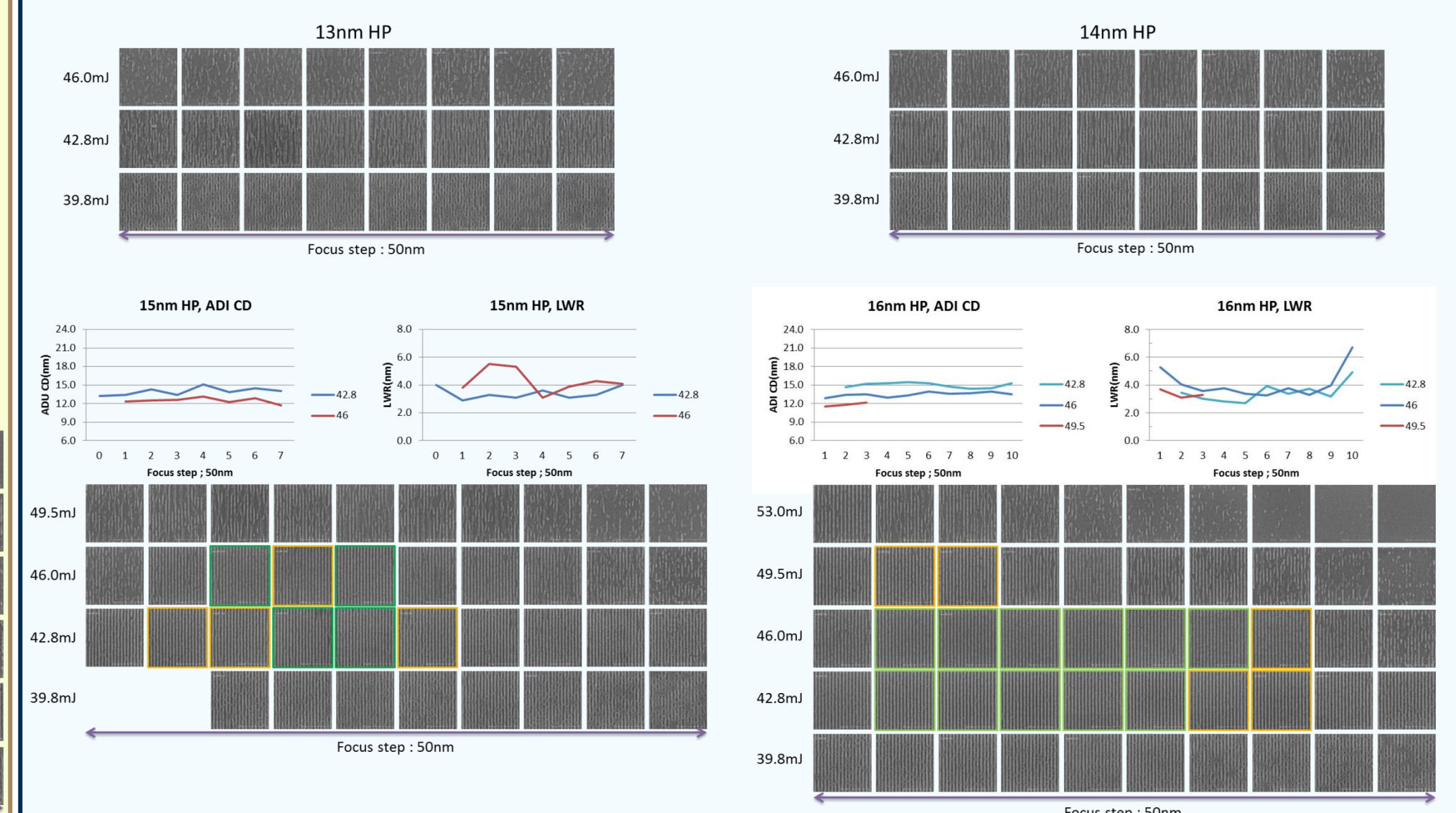
	20nm	19nm	18nm	17nm	16nm	15nm	14nm	13nm
H 33.6mJ								
I 46.0mJ								
J 15.6mJ								
K 19.4mJ								
L 15.5mJ								
M 15.4mJ								

BMET, Pseudo PSM
FT 30nm, 35nm
Underlayers



- Resist H and I showed 15nm resolution.
- Many of suppliers are making progress with patterning performance

Process window of I



- Resist I had reasonable process window at 16nmHP.

5. Summary

- Resists are showing gradual improvement in resolution and LWR, best line and space resists sample showed 15nm HP and below resolution.
- Photospeed is still an issue
 - Resists with improved LWR are all above 20mJ/cm²
 - Contact hole resist are all 35mJ/cm² or higher in dose to size
- CDU is improving and some of them showed sub 3nm CDU.